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Description

TECHNICAL FIELD

This invention relates to liquid dispensers for repetitively discharging substantially equal amounts of liquid with highly reproducible output flow as a function of time.

BACKGROUND OF THE INVENTION

The manufacture of semiconductor apparatus and of various recording media require the application of controlled amounts of liquid to the surface of material in process. It is common practice to dispense liquid to a surface of a wafer or disk which is spinning about it's major axis. The spinning motion causes the liquid to flow evenly over the surface of the disk or wafer. In such applications, uniformity of product requires that the volume of the liquid dispensed and the output flow rate as a function of time be accurately controlled and reproducible.

US-A-4,690,621 shows a pneumatically operated diaphragm pump which has an integral filter and pneumatically operated valves which are integrated into the pump body.

US-A-4,483,665 is an example of a bellows type pump which utilizes an external filter, and air under pressure is employed to compress the bellows to discharge liquid from the pump.

As noted earlier herein, the volume dispensed per cycle of pump operation and the rate of discharge as a function of time are important in achieving uniformity of distribution of the liquid to the surface being coated and to uniformity of product.

The use of air or other gases as a driving force, because of their compressibility, does not permit either accurate control of the volume dispensed per cycle or of the dispenser output flow as a function of time.

EP-A-0,077,908 shows a diagphram pump used to push solvent under pressure through a silica alumina separation column. This pump is designed to deliver a constant flow rate.

US-A-4,347,131 shows a syringe type pump designed to deliver a measured volume of solution to be separated into a high performance liquid chromatography machine.

DISCLOSURE OF THE INVENTION

Acoordingly the present invention is directed to a precision liquid dispenser for dispensing precise amounts of a pumped liquid at controlled rates, especially but not exclusively a system for dispensing liquids used in the manufacture of components which require a layer of liquid to be placed thereon, comprising :

a) a positive displacement liquid pump having a flexible diaphragm (111), a pump chamber (110) and a driving chamber (106) on opposite sides of the diaphragm (111);

b) an inlet channel (114) and an outlet channel (122), each being capable of fluid communication with the pump chamber (110);

c) a hydraulic driving system for selectively deforming the diaphragm (111);

in which there are:

d) valve means (125) for selectively putting the inlet channel (114) in fluid communication between a source of liquid (113) to be dispensed and the pump chamber (110), and for selectively putting the outlet channel (122) in fluid connection between the pump chamber (110) and a dispensing port (124);

e) means for controlling the valve means (125) in coordination with the means for controlling the hydraulic system;

f) means (150) for controlling the hydraulic system;

g) the hydraulic system including a piston (107) adjacent to the driving chamber (106) for maintaining a driving liquid in fluid communication with the diaphragm (111);

h) the means (150) for controlling the hydraulic system including a reversible stepping motor (102), motion converting means for changing a rotative output motion of the motor (102) into axial motion of the piston (107) to provide bidirectional linear motion of the piston 107);

i) the motion converting means comprising a threaded coupling (120) between the motor (102) and the piston (107); and

j) a source (151) of electrical signals for controlling the motor (102).

Further advantageous features are described in subclaims 2 to 5.

Advantageously, hydraulic, as opposed to pneumatic, control of the pump diaphragm provides for accurate, reproducible control of both output volume and flow as a function of time; and the use of a stepping motor and a controlled source of power permits easy control of output volume, control of output flow as a source of time, and rapid cycling of the liquid dispenser.

BRIEF DESCRIPTION OF THE DRAWINGS

The single figure illustrates a liquid dispenser in accordance with Applicant's invention.

DETAILED DESCRIPTION OF THE INVENTION

A liquid dispenser in accordance with this invention is generally supplied as a O.E.M. (Original

Manufacturer Equipment) product for integration into a processing system of other manufacturers. In a typical application in semiconductor processing, relatively viscous, reactive materials e.g., positive and negative photoresist, are dispensed in volumes ranging from less than 1 cc per cycle to greater than 15 cm^3 per cycle of dispenser operation; and in some media coating operations, volumes on the order of 60 cm^3 are dispensed at a rate of 0.2 cm^3/sec to 2.0 cm^3/sec or more. The rate of discharge during a discharge cycle may be varied with time to achieve the desired product coating. For example, the rate of discharge is controlled per cycle, and positive cut off of flow is achieved by drawback of the fluid.

The dispenser assembly comprises a frame 100 with mounting feet 180. A motor mounting plate 101 is attached to the frame as shown in the drawing; and a reversible stepping motor 102 is attached to mounting plate 101 by fixtures 103.

A screw drive shaft 120 is attached to the motor shaft 118 by a set screw (not shown in the drawing) for positive rotation therewith. External threads on the drive shaft 120 cooperate with mating internal threads of coupling member 121. The mating threads are closely matched to assure precision control of bi-directional linear motion of coupling 120. Coupling member 121 passes through opening 105 in body 104 and is attached to piston 107. Accordingly, piston 107 follows linear motion of coupling 121. Sealing ring 108 prevents leakage of hydraulic fluid as piston 107 is moved up and down in cavity 106. When hydraulic fluid is initially introduced into chamber 106 between diaphragm 111 and piston 107, any air in that chamber is vented through bleed port 160. Accordingly, the hydraulic system is closed except for bleeding of air captured in the system.

The tubular dispenser body 109 has first and second opposing surfaces 190 and 191. A dispenser cavity 110 is formed in the body 109 at the surface 191 and an output orifice 117 couples the cavity 110 to the surface 190. A diaphragm 111 covers the cavity 110 at the surface 191 and extends beyond the sealing O ring 127 which is seated in a depression in body 104. Threaded bolts 181 pass through passages in body 109 and engage threads in body 104. The diaphragm 111 is held by compression between bodies 104 and 109. The sealing O rings 127 and 128 respectively prevent leakage of the liquid being dispensed and hydraulic fluid.

The solenoid valve assembly 125, under the control of signals from the dispenser control logic 150, selectively connects valve input port 115 to the valve input/output port 116, or connects the input/output port 116 to the valve output port 112. Valve control signals from control logic 150 are coordinated in time with control signals for the reversible stepping motor 102. The valve assembly 125 may comprise two independent, solenoid operated valves, or a two position three port solenoid valve which provides the above enumerated flow paths. The path from input port 115 to input/output port 116 is employed to introduce liquid to be dispensed into cavity 110 from the liquid source 113; and the path from port 116 to output port 112 is employed to transmit liquid from the dispenser to the output filter 123.

A cycle of dispenser operation comprises the following functions: operate solenoid to close the path between ports 116 and 112 and open path from port 115 to port 116; operate motor 102 to draw piston 107 downward to remove hydraulic pressure from the lower side of diaphragm 111 to introduce fluid into cavity 110 from source 113 via conduit 114, port 115, a passage in valve 125, port 116, conduit 182 and port 117; operate solenoid to open the path between ports 116 and 112 to close the path from port 115 to port 116; operate motor 102 to drive piston 107 upward to discharge liquid from chamber 110 to output conduit 124 by deforming diaphragm 111; after the defined volume of fluid is dispensed, operate motor 102 to drive piston 107 slightly downward to draw fluid back into conduit 124 to prevent unintended afterflow to the product; and repeat the above described cycle.

During each cycle of operation, the volume of fluid introduced into the system from the source 113 equals the volume dispensed. The above cycle may include a pre-dispense operation in which a small amount of fluid is discharged to waste before the main volume is dispensed to the product. Predispense is achieved by operating the motor 102 to drive the piston 107 slightly upward and momentarily stopping to permit the product to the placed in the path of liquid discharged from conduit 124.

The volume of fluid dispensed in a cycle is directed related to the vertical motion of piston 107, and vertical motion of piston 107 is directly related to the number of pulses delivered to motor 102 from the dispenser control logic 150 via the path 151. At the time of manufacture, the dispenser is calibrated to define the motor control signals required to achieve target volumes to be dispensed and the flow patterns from those volumes. The manual input 154 control permits an operator to define dispenser operating parameters, e.g., the volume of liquid to be dispensed in a cycle of dispenser operation and the rates at which liquid is to be dispensed as a function of time during a cycle of dispenser operation. Display 126 displays the selected parameters and other system data to the operator.

The invention has been described with respect to a preferred embodiment; however, persons

skilled in the art may provide variations in implementation without departing from the scope of the invention.

Claims

1. A precision liquid dispenser for dispensing precise amounts of a pumped liquid at controlled rates, especially but not exclusively a system for dispensing liquids used in the manufacture of components which require a layer of liquid to be placed thereon, comprising :
   a) a positive displacement liquid pump having a flexible diaphragm (111), a pump chamber (110) and a driving chamber (106) on opposite sides of the diaphragm (111);
   b) an inlet channel (114) and an outlet channel (122), each being capable of fluid communication with the pump chamber (110);
   c) a hydraulic driving system for selectively deforming the diaphragm (111);

   characterised by

   d) valve means (125) for selectively putting the inlet channel (114) in fluid communication between a source of liquid (113) to be dispensed and the pump chamber (110), and for selectively putting the outlet channel (122) in fluid connection between the pump chamber (110) and a dispensing port (124);
   e) means for controlling the valve means (125) in coordination with the means for controlling the hydraulic system;
   f) means (150) for controlling the hydraulic system;
   g) the hydraulic system including a piston (107) adjacent to the driving chamber (106) for maintaining a driving liquid in fluid communication with the diaphragm (111);
   h) the means (150) for controlling the hydraulic system including a reversible stepping motor (102), motion converting means (120,121) for changing a rotative output motion of the motor (102) into axial motion of the piston (107) to provide bi-directional linear motion of the piston 107);
   i) the motion converting means comprising a threaded coupling (120) between the motor (102) and the piston (107); and
   j) a source (151) of electrical signals for controlling the motor (102).

2. A precision liquid dispenser according to claim 1, characterised in that the means (150) for controlling the hydraulic system includes manual input means (164) for defining the volume to be dispensed in a cycle of dispenser operation.

3. A precision liquid dispenser according to claim 1 or claim 2, characterised in that the means for controlling the hydraulic system includes manual input means for defining the rates at which liquid is to be dispensed as a function of time in a cycle of dispenser.

4. A precision liquid dispenser according to any preceding claim, characterised in that the threaded coupling (120) includes internal threads on an extension (121) of the piston and external threads on a shaft (120) extending from the motor (102), the internal and external threads being closely matched.

5. A precision liquid dispenser according to any preceding claim, characterised in that the pump includes a bleed port (160) communicating with the driving chamber (106).

Patentansprüche

1. Präzisionsflüssigkeitsausgeber zur Abgabe von genauen Mengen einer gepumpten Flüssigkeit bei gesteuerten Geschwindigkeiten, insbesondere, wenn auch nicht ausschließlich, ein System zum Ausgeben von Flüssigkeiten, wie sie bei der Herstellung von Bauteilen verwendet werden, bei denen auf diesen eine Flüssigkeitsschicht angeordnet werden muß mit folgenden Bestandteilen:
   a) Eine Flüssigkeitspumpe positiver Verdrängung, welche eine flexible Membran (111), eine Pumpenkammer (110) und eine Antriebskammer (106) aufeinander gegenüberliegenden Seiten der Membran (111) aufweist;
   b) einen Einlaßkanal (114) und einen Auslaßkanal (122), welche jeweils eine flüssigkeitsführende Verbindung mit der Pumpenkammer (110) herstellen können;
   c) ein hydraulisches Antriebssystem zur wahlweisen Verformung der Membran (111);

   gekennzeichnet durch folgende Bestandteile und Einzelheiten:

   d) Ventileinrichtungen (125), um wahlweise den Einlaßkanal (114) in flüssigkeitsführende Verbindung mit einer Quelle (113) der auszugebenden Flüssigkeit und der Pumpenkammer (110) zu setzen, und um wahlweise den Auslaßkanal (122) in flüssigkeitsführende Verbindung mit der Pumpenkammer (110) und einer Ausgabeöffnung (124) zu setzen;
   e) Einrichtungen zum Steuern der Ventileinrichtungen (125) in Abstimmung mit den Einrichtungen zum Steuern des hydrauli-

schen Systems;
f) Einrichtungen (150), um das hydraulische Systems zu steuern;
g) das hydraulische System enthält einen Kolben (107) nahe der Antriebskammer (106), um eine Antriebsflüssigkeit in flüssigkeitsführender Verbindung mit der Membram (11) zu halten;
h) die Einrichtungen (150) zum Steuern des hydraulischen Systems enthalten einen umkehrbaren Schrittmotor (102), Bewegungsumwandlungseinrichtungen (120, 131) um eine drehende Ausgangsbewegung des Motors (102) in eine Axialbewegung des Kolbens (107) umzuwandeln, um dadurch eine bidirektionale, geradlinie Bewegung des Kolbens (107) zu erzeugen;
i) die Bewegungsumwandlungseinrichtungen enthalten eine mit Gewinde versehene Kupplung (120) zwischen dem Motor (102) und dem Kolben (107); und
j) eine Quelle (151) elektrischer Signale zur Steuerung des Motors (102).

2. Präzisionsflüssigkeitsausgeber nach Anspruch 1, **dadurch gekennzeichnet**, daß die Einrichtungen (150) zum Steuern des hydraulischen Systems manuelle Eingabeeinrichtungen (164) enthalten, um das in einem Arbeitszyklus des Flüssigkeitsausgebers abgegebene Volumen festzulegen.

3. Präzisionsflüssigkeitsausgeber nach Anspruch 1 oder 2, **dadurch gekennzeichnet**, daß die Einrichtungen zum Steuern des hydraulischen Systems manuelle Eingabeeinrichtungen enthalten, um die Geschwindigkeiten mit denen Flüssigkeit ausgegeben werden soll, als Funktion der Zeit in einem Arbeitszyklus des Flüssigkeitsausgebers festzulegen.

4. Präzisionsflüssigkeitsausgeber nach einem der vorstehenden Ansprüche, **dadurch gekennzeichne**, daß die mit Gewinde versehene Kupplung (120) Innengewinde auf eine Verlängerung (121) des Kolbens und Außengewinde auf einer Welle (120) aufweist, welche von dem Motor (102) ausgeht, wobei die Innengewinde und die Außengewinde in engen Toleranzen angepaßt sind.

5. Präzisionsflüssigkeitsausgeber nach einem der vorstehenden Ansprüche, **dadurch gekennzeichnet**, daß die Pumpe eine Entlastungsöffnung (160) aufweist, die mit der Antriebskammer (106) in Verbindung steht.

Revendications

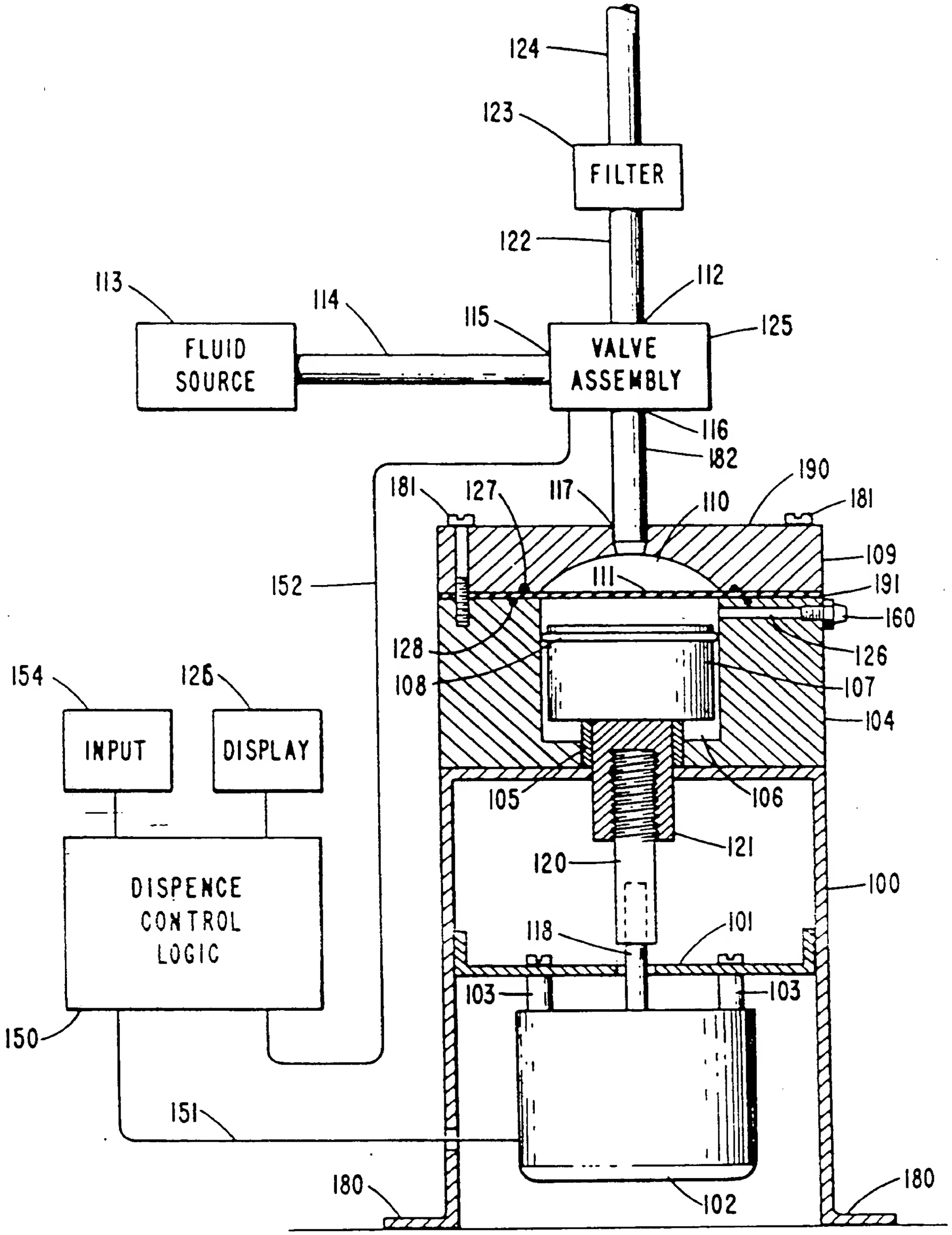
1. Un distributeur de liquide de précision pour distribuer des quantités précises d'un liquide pompé avec des débits commandés, et en particulier, mais non exclusivement, un système pour distribuer des liquides qui est utilisé dans la fabrication de composants qui exigent de placer une couche de liquide sur ces composants, comprenant :
   a) une pompe à liquide de type volumétrique ayant une membrane flexible (111), une chambre de pompe (110) et une chambre d'entraînement (106) de part et d'autre de la membrane (111) ;
   b) un conduit d'entrée (114) et un conduit de sortie (122), chacun d'eux étant capable d'établir une communication pour un fluide avec la chambre de pompe (110) ;
   c) un système d'entraînement hydraulique pour déformer sélectivement la membrane (111) ;
   caractérisé par
   d) une structure de vanne (125) pour faire en sorte que le conduit d'entrée (114) qui est relié à une source de liquide (113) à distribuer, soit mis sélectivement en communication avec la chambre de pompe (110), et pour faire en sorte que le conduit de sortie (122) qui est relié à un orifice de distribution (124), soit mis sélectivement en communication avec la chambre de pompe (110) ;
   e) des moyens pour commander la structure de vanne (125) en coordination avec les moyens destinés à commander le système hydraulique;
   f) des moyens (150) pour commander le système hydraulique ;
   g) le système hydraulique comprenant un piston (107) adjacent à la chambre d'entraînement (106), pour maintenir un liquide d'entraînement en communication avec la membrane (111) ;
   h) les moyens (150) destinés à commander le système hydraulique comprenant un moteur pas à pas réversible (102), des moyens de conversion de mouvement (120, 121) destinés à transformer un mouvement de sortie de rotation du moteur (102) en un mouvement axial du piston (107), pour produire un mouvement rectiligne bi-directionnel du piston (107) ;
   i) les moyens de conversion de mouvement comprenant un accouplement fileté (120) entre le moteur (102) et le piston (107) ; et
   j) une source (151) de signaux électriques pour commander le moteur (102).

2. Un distributeur de liquide de précision selon la revendication 1, caractérisé en ce que les moyens (150) destinés à commander le système hydraulique comprennent des moyens d'entrée manuels (164) pour définir le volume à distribuer au cours d'un cycle de fonctionnement du distributeur.

3. Un distributeur de liquide de précision selon la revendication 1 ou la revendication 2, caractérisé en ce que les moyens destinés à commander le système hydraulique comprennent des moyens d'entrée manuels pour définir les débits avec lesquels un liquide doit être distribué, en fonction du temps au cours d'un cycle du distributeur.

4. Un distributeur de liquide de précision selon l'une quelconque des revendications précédentes, caractérisé en ce que l'accouplement fileté (120) comprend un filetage interne sur un prolongement (121) du piston et un filetage externe sur une tige (120) qui s'étend à partir du moteur (102), les filetages interne et externe étant étroitement adaptés.

5. Un distributeur de liquide de précision selon l'une quelconque des revendications précédentes, caractérisé en ce que la pompe comprend un orifice de purge (160) qui communique avec la chambre d'entraînement (106).


124
123
FILTER
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125
FLUID SOURCE
VALVE ASSEMBLY
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152
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191
160
128
126
108
107
154
156
104
INPUT
DISPLAY
105
106
121
120
100
DISPENCE CONTROL LOGIC
118
101
103
103
150
151
180
102
180